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Diversity and local knowledge of antivenom medicinal plants in the Poro region (Northern Côte d'Ivoire)

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Abstract

This study aims to document the medicinal plants used by local populations for antivenom in the Poro region of northern Côte d'Ivoire. To do this, an ethnobotanical survey was carried out in the departments of Korhogo, Dikodougou, and Sinématiali, through semi-structured interviews with a questionnaire. The respondents were individuals knowledgeable about medicinal plants. A total of 106 people were interviewed, most of whom were men (96.23%), mostly uneducated (94%), and over 50 years old (62.26%). We recorded 51 species, spread over 50 genera and 30 families, with Fabaceae being the most common family (11 species). Microphanerophytes were the most abundant (46%), trees were the most common growth form (37.27%), and leaves were the most frequently used plant part (44.95%). Decoction was the main preparation method (41.17%), and smearing (rubbing) was the most common mode of application (50.98%). The species most frequently mentioned by respondents were *Sarcocephalus latifolius* (16 citations, or 15.09%), *Securidaca longepedunculata* (9 citations, or 8.89%), followed by *Piliostigma thonningii*, *Vitellaria paradoxa*, and *Spermacoce verticillata*, each cited four times (3.77%). These findings could provide a valuable basis for future phytochemical and pharmacological research to control venomous bites.

Keywords: Ethnobotany; Envenomation; Medicinal Plants; Poro Region; Côte d'Ivoire

1. Introduction

Medicinal plants play an essential role in healthcare worldwide, particularly in Africa, where more than 80% of the population uses traditional medicine [1]. In Côte d'Ivoire, the use of medicinal products prescribed by traditional medicine practitioners (TMPs) to prevent and treat both natural and mystical diseases is deeply rooted in the cultural identity of local ethnic communities [2, 3]. Nearly 1,500 species of medicinal plants have been identified within the Ivorian vascular flora, which is estimated at 3,880 species, distributed across three main agro-ecological zones: forest, transition, and savanna regions [4, 5, 6, 7, 8]. Traditional medicine, considered a practice deeply rooted in the customs of rural communities, is perceived as a true sociocultural heritage passed down from generation to generation [3]. Medicinal plants are likely to have countless pharmacological properties that can be used to treat or limit many human diseases [9]. Therefore, in order to bring Western medicine and traditional medicine together, several studies have been conducted on endogenous knowledge and the identification of bioactive molecules to establish the scientific basis for the biological activities of medicinal plants in the Ivorian pharmacopoeia [10, 11, 12, 13, 14, 15]. Although these studies have focused on public health conditions of particular concern (high blood pressure, diabetes, sickle cell disease,

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candidiasis, oral diseases, digestive disorders, malaria and various dermatophytoses), few studies have addressed envenomation caused by arachnid stings, reptile bites or bee stings, which represent a major public health problem, particularly in sub-Saharan Africa where access to antivenom molecules remains limited. These envenomations constitute a global health challenge. Scorpion and spider stings can cause serious symptoms that can lead to death in humans [16, 17, 18]. As for snake bites, global data indicate that each year, approximately 5.4 million people are bitten, resulting in 2.7 million cases of envenomation and 137,880 deaths [1]. In light of this situation, collecting data on indigenous knowledge of antivenomous medicinal plants could contribute to the development of bioactive antivenomous molecules by modern medicine for use in treating cases of envenomation.

This study fits into this context, and its overall objective is to contribute to cataloging the flora and indigenous knowledge of anti-venom medicinal plants used in the Poro region to promote their use in the public health system. Specifically, the aim was to (1) inventory the anti-venom medicinal plants used by local populations in the Poro region and (2) identify the plant parts utilized, as well as the preparation and administration methods of these remedies.

2. Material and Method

2.1. Study area

The Poro Region is located in the far north of Côte d'Ivoire, between latitudes 8°26′ and 10°27′ North and longitudes 5°17′ and 6°19′ West [19]. It covers an area of 13,400 km^2 and comprises four departments: Korhogo, Sinématiali, Dikodougou, and M'Bengué [20] (Figure 1). This region is characterized by a Sudanian-type climate with alternating dry and rainy seasons [21]. The average annual rainfall is about 1,200 mm, with significant interannual variability. Average annual temperatures range between 24°C and 29°C. The soils are predominantly ferrallitic, moderately to weakly desaturated, and ferruginous. The study area belongs to the Sub-Sudanian sector, characterized by dry dense forests, open forests, wooded savannas, and shrub savannas. The population is estimated at 1,040,500 inhabitants, with the Senoufo people being the main ethnic group [22].

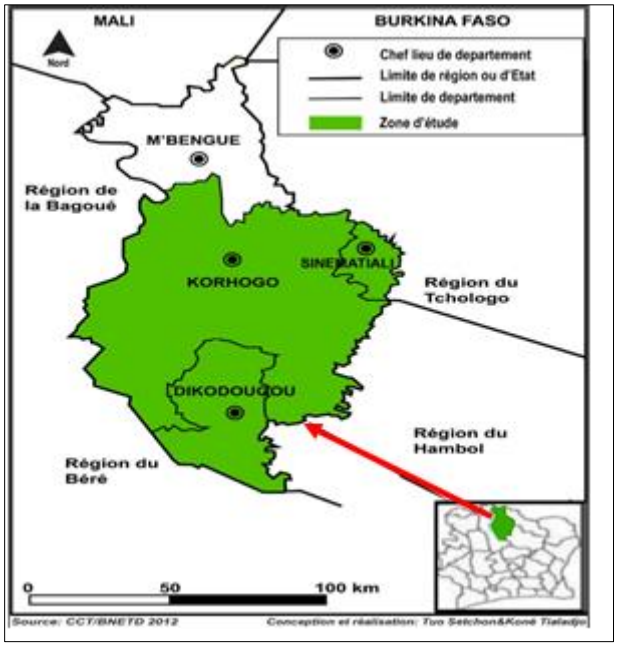

Figure 1 Map of the study area

2.2. Data Collection

The ethnobotanical survey was conducted in the Poro region using 106 questionnaire forms and following a stratified probabilistic sampling method [23], which covered three departments (Korhogo, Dikodougou, Sinématiali) and 21 localities, with seven localities per department (Table 1). The survey was carried out among herbalists, traditional practitioners (healers), and farmers, and was based on questionnaires collecting sociodemographic data, local names of plants, plant parts used, methods of preparation and administration, current usage status, and treated ailments. Floristic data collection consisted of creating a herbarium board from fresh plant samples collected in the field. After the herbaria specimens were made, the plant species were identified, either directly in the field for certain species, or by comparing

the samples with those in the herbarium of the National Centre for Floristics (CNF) at Felix Houphouët Boigny University. In this study, we followed Cronquist's nomenclature (1981) [24] for the identification of different plant species and the APG IV classification (2016) [25] at the family level.

Table 1 Distribution of surveys according to the strata of the study area

Strates	Departments	Localities
Strate 1	Korhogo	Korhogo, Karakoro,Torgokaha, Kpatrakaha, kanoroba, Tallere, Odia
Strate 2	Dikodougou	Boron, Marha, Dikodougou, Poundia, Nangakaha, karakpo, et Sounzorisso
Strate 3	Sinematiali	Dokaha, Kalokaha, Nakouroubelekaha 1, Kafiekaha, Lablekaha, ziekaha et Sinématiali

2.3. Data analysis

For data analysis, the ethnobotanical data were entered into Excel software. Using this software, pivot tables, histograms, and pie charts were created, and the proportions of the considered variables were calculated. Regarding sociodemographic data, the profile of respondents (age, gender, education level, professional status) was determined according to the model of [23], and ethnobotanical indices were calculated using the following mathematical formulas:

Citation Frequency (CF), which evaluates the reliability of the information received and the level of plant knowledge among the surveyed population [26]. It expresses the percentage of citations of a species relative to the total number of respondents.

$$CF=n/N\times100$$

Where **n** is the number of people who cited the species and **N** is the total number of people surveyed.

Consensus Index (CI), which assesses the degree of agreement among respondents on plant species used against the same ailment in the study area. It expresses the homogeneity of ethnobotanical information, according to [27, 28, 29]:

$$CI=(N-Ne)/(N-1)$$

Where **N** is the number of times the ailment is cited and **Ne** is the total number of species used to treat it.

Frequency of Preparation Method (FPM), which is the ratio of the number of times a preparation method is used to the total number of recipes [30]

$$FPM=n/N\times100$$

Where **n** is the total number of times the preparation method is used and **N** is the total number of recipes.

Frequency of Use of an Administration method (FUA), which is the ratio of the number of times an administration method is cited to the total number of recipes

$$FUA=n/N\times100$$

Where **n** is the total number of times the administration method is cited and **N** is the total number of recipes.

For floristic analysis, species richness (number of species, genera, and families) for each department was determined. The floristic composition was analyzed according to morphological types, biological types [6, 31, 32], and chorological types [33]. The degree of floristic similarity among the floras of the different departments was measured using a Venn diagram and the Sørensen similarity coefficient (Cs), calculated using the following formula [34]:

$$Cs=2C/(a+b)\times100$$

Where **a** is the number of species in a list belonging to site A, **b** is the number of species in a list belonging to site B, and **c** refers to the number of species common to both sites (A and B) being compared. This coefficient ranges from 0 to 100%. The hypothesis of similarity or resemblance is accepted when the coefficient is greater than 50% [35].

3. Results

3.1. Utilization of medicinal plants by gender and age

A total of 106 individuals were interviewed during the surveys conducted in the three departments. Among all respondents, men were predominant (Figure 2A), with proportions ranging from 90.91% in Sinématiali to 98.04% in Dikodougou, while women represented proportions between 1.96% in Dikodougou and 9.09% in Sinématiali. Regarding the age distribution of respondents, the age group over 50 years old was the most represented (Figure 2B), with rates ranging from 49.02% in Dikodougou to 76.74% in Korhogo.

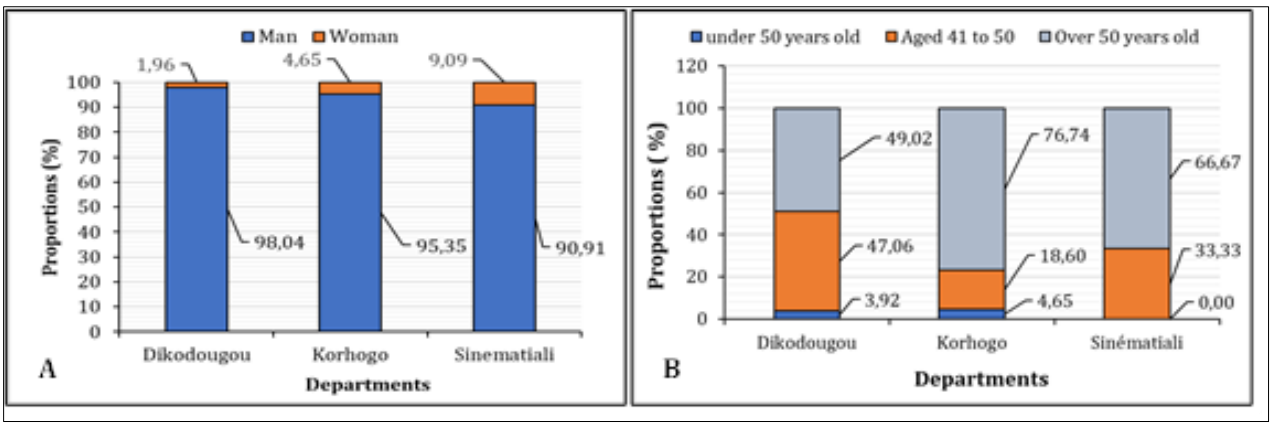

Figure 2 Distribution of respondents by gender (A) and age (B)

3.2. Utilization of medicinal plants by educational level and occupation

Among the respondents, the majority of those who possessed knowledge about anti-venom plants were unschooled, with a general rate of 94.34% (Figure 3A). Across departments, this rate ranged from 90.20% in Dikodougou to 100% in Korhogo. Professionally, traditional practitioners constituted the majority of respondents in Korhogo (74.42%) and Dikodougou (62.75%), while farmers were the majority in Sinématiali with a rate of 63.64% (Figure 3B). The Senoufo ethnic group accounted for 89.72% of respondents, compared to 10.28% for the Malinké across the study area.

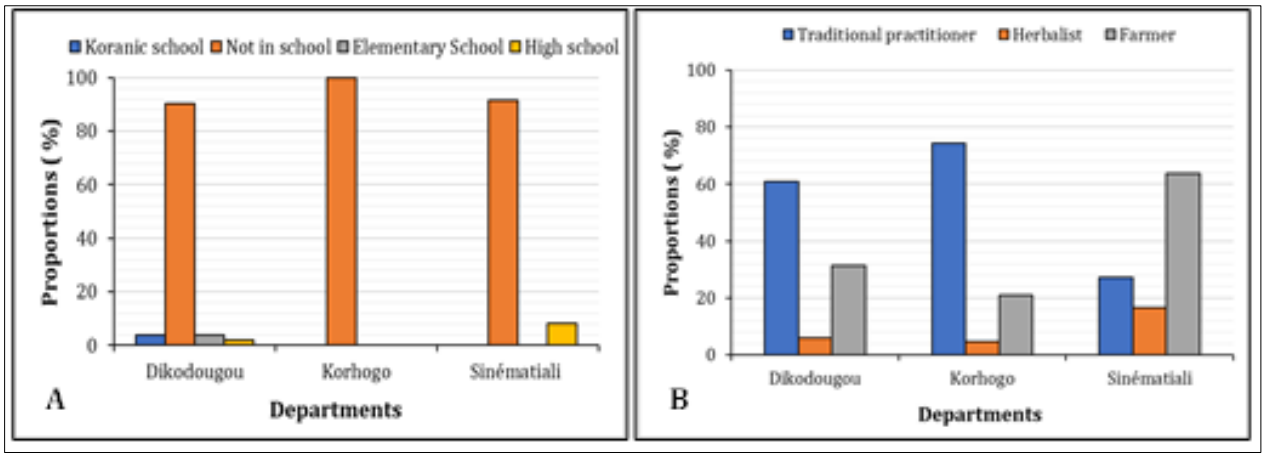

Figure 3 Distribution of respondents by educational level (A) and occupation (B)

3.3. Species richness and floristic composition

Floristic analysis identified 51 plant species distributed across 50 genera and 30 families. The department of Dikodougou had the highest species richness (36 species, 70.59%), while Sinématiali recorded the lowest, with 11 species (21.57%) (Table 2). The most species-rich families were Fabaceae (11 species), Euphorbiaceae (5 species), Rubiaceae (4 species), and Rutaceae (3 species) (Figure 4).

Four morphological types (trees, shrubs, lianas, and herbs) were identified among the antivenom medicinal species. Shrubs were the most represented across all sites with 21 species (41.18%), while lianas were the least represented with 8 species (15.69%) (Table 3). In terms of biological types, microphanerophytes were the most abundant, with 29 species (56.86%), while the other biological types were less represented, each with three species (5.88%). This trend was similar across the different departments surveyed (Figure 5A). The species belonging to the Guineo-Congolian/Sudanian transition zone (GC-SZ) were the most numerous across all departments, with proportions ranging from 36.36% (Sinématiali) and 56.52% (Dikodougou; Figure 5B).

Table 2 Floristic richness of different departments in terms of anti-venom species

Taxonomic units	Korhogo	Dikodougou	Sinématiali	Total flora
Number of species	23	36	11	51
Number of genera	23	35	11	50
Number of families	14	22	9	30

Table 3 Morphological types of recorded species

Departments	Trees	Shrubs	Herbs	Lianas
Dikodougou	6	17	8	5
Korhogo	5	9	5	4
Sinematiali	2	4	4	1
Total flora	9	21	13	8

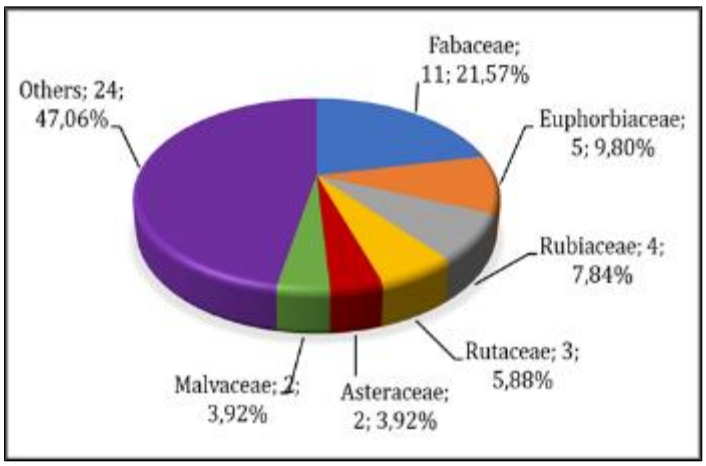

Figure 4 Spectrum of the most important plant families in the flora

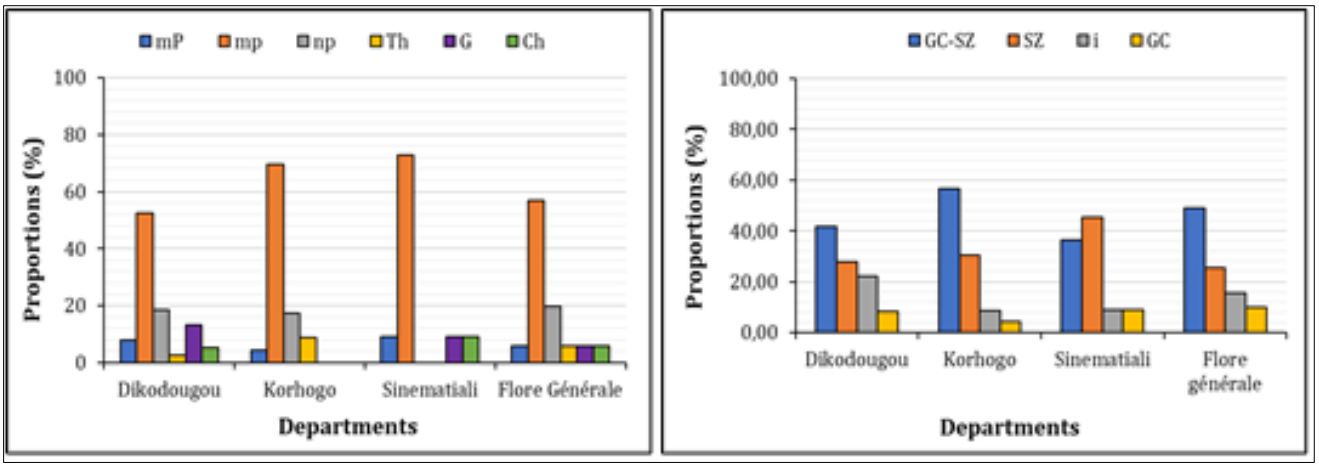

Figure 5 Spectrum of biological types (A) and chorological types (B) of the flora

3.4. Floristic similarity

The calculated Sorensen similarity coefficient showed no significant floristic similarity among the departments of the Poro region (Table 4). The Venn diagram established indicates that four species (7.84%) were common to all three departments studied: *Sarcocephalus latifolius*, *Securidaca longepedunculata*, *Vitellaria paradoxa*, and *Daniellia olivera*. The department of Dikodougou had the highest number of specific species (23 species), while Sinématiali had the lowest, with only 4 species (Figure 6).

Table 4 Similarity index distribution among departments

	Korhogo	**Dikodougou**	**Sinématiali**
Korhogo	100	23.73	17.65
Dikodougou	23.73	100	4.25
Sinématiali	17.65	4.25	100

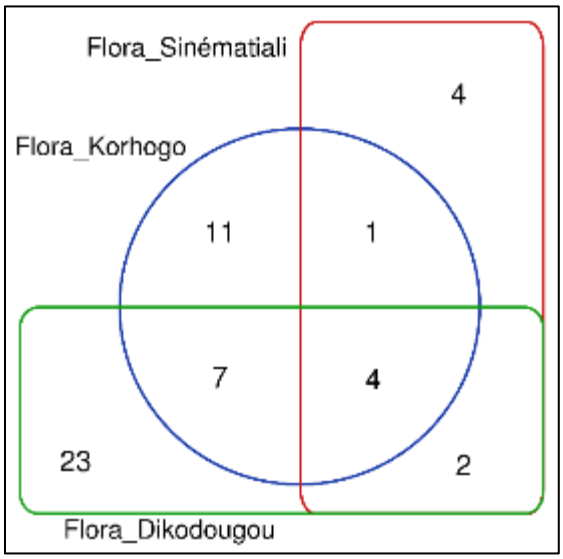

Figure 6 Relationship among the flora of different departments

From the ethnobotanical investigation, six types of envenomation (bee, ant, wasp, scorpion, snake, and shrew bites) were reported by respondents during the study. Wasp stings had the highest consensus index value (0.83), while scorpion stings had the lowest value (0.25) (Table 5). The most frequently cited species is *Sarcocephalus latifolius* (15.09%). This is followed by *Securidaca longepedunculata* (8.89%), *Daniellia olivera* (Figure 7), *Manihot esculenta*, *Piliostigma thonningii*, *Spermacoce verticillata*, and *Vitellaria paradoxa* (3.77% each) for all three departments (Table 6).

Eight preparation methods are used to facilitate the administration of active compounds: decoction, roasting, bleeding (bloodletting), pounding (grinding), fumigation, chewing, powdering, and expression. Decoction, powdering, and bleeding are the three most commonly used preparation methods in the three departments, with respective rates of 28.26% in Korhogo, 31.37% in Dikodougou, and 33.33% in Sinématiali (Figure 7A). Additionally, four main administration methods were identified during the survey: smearing (rubbing), oral administration, mouthwash (mouthrinse), and inhalation. Among these, smearing is the most widely used method, with proportions exceeding 40% in all three departments (Figure 7B).

Table 5 Consensus index values according to envenomation types

Envenomation types	N	Ne	CI
Bee	14	8	0.46
Ant	6	4	0.40
Wasp	13	3	0.83
Shrew	1	1	0
Scorpion	25	19	0.25
Snake	62	36	0.43

Table 6 Most frequently cited anti-venom medicinal plants in the study area

Species	Citation Frequency (%)
Sarcocephalus latifolius	*15,09*
Securidaca longepedunculata	*8,49*
Daniellia olivera	*3,77*
Manihot esculenta	*3,77*
Piliostigma thonningii	*3,77*
Spermacoce verticillata	*3,77*
Vitellaria paradoxa	*3,77*

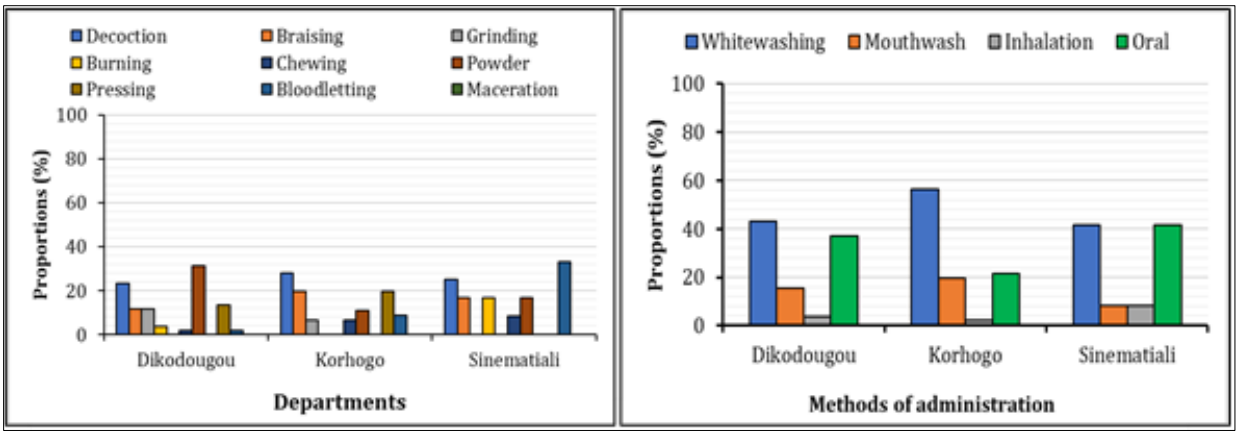

Figure 7 Distribution of plants by preparation method (A) and administration method (B)

4. Discussion

4.1. Sociodemographic profile of respondents

The results obtained during the survey indicate that traditional knowledge of antivenom plants is mainly held by older men, often uneducated, who generally work as traditional healers. This distribution can be explained by the often secret and hereditary nature of this knowledge. Experience accumulated with age is the main source of information at the local level on the use of plants in traditional medicine [23, 36, 37]. However, some authors report that knowledge of medicinal plants is often held by women, particularly for the care of children [23, 38]. This difference in results could be explained by the fact that specific medical knowledge, such as the one studied here, is associated with sacred knowledge traditionally entrusted to men.

4.2. Species richness and floristic composition

The richness of 51 species identified in this study reveals a relatively low plant diversity. Indeed, this richness represents approximately 3.4% of the estimated 1,500 medicinal vascular plant species in Côte d'Ivoire. However, this flora is highly representative of the medicinal plant flora of the Sudanian zone in northern Côte d'Ivoire. It is more diverse than the medicinal flora of anti-venom plants used by the populations of Aboisso [39]. The species recorded during the survey were dominated by Fabaceae (11 species), followed by Euphorbiaceae (5 species). The dominance of Fabaceae is a characteristic of the flora for all usage categories in tropical and intertropical zones [37, 40, 41]. Moreover, this family's high representation is partly due to the inclusion of former subfamilies Caesalpiniaceae, Mimosaceae, and Papilionaceae under Fabaceae [25]. The abundance of microphanerophytes observed in this flora could be explained by the fact that the Poro region belongs to the Sudanian savanna zone, which is characterized by shrub species [15]. These biomorphological types are frequently found in the immediate environment of users and are easily accessible for harvesting plant parts [42].

4.3. Floristic similarity

The low similarity coefficient values calculated do not show any significant floristic resemblance among the different departments. This indicates that knowledge about the use of anti-venom medicinal plants varies among sociodemographic groups. It demonstrates that each Senoufo sub-ethnic group has a different perception regarding the utilization of species for treating envenomation cases. Similar results were reported by [43] in an ethnobotanical study of species belonging to the Acanthaceae family.

4.4. Ethnobotanical assessment

Among the six types of envenomation identified, wasp stings recorded the highest consensus factor value (0.83). This reflects strong collective knowledge about plants used for treating wasp stings. A value greater than 0.50 indicates shared pharmacopoeia knowledge, compared to envenomations caused by snakes, scorpions, and bees, which have consensus indices below 0.50, indicating a lower level of agreement among informants. These results corroborate those of [44], who obtained a consensus index of 0.72 in the category of plants used against poisons in Congo.

The most frequently cited species by respondents were: *Sarcocephalus latifolius* (15,09 %), *Securidaca longepedunculata* (8,89 %), *Piliostigma thonningii* (3,77 %), *Manihot esculenta* (3,77 %) and, *Vitellaria paradoxa* (3,77 %). Many authors have also identified these species as major plants for the treatment of snakebite envenomations [37, 39, 45]. Decoction emerged as the most widely used preparation method in the Poro region (41.17%). This method, which allows the extraction of maximum active principles while reducing the toxicity of certains plants [46], has also been identified in other studies conducted in Côte d'Ivoire, Benin, and Morocco as the most common preparation method [37, 45, 47]. However, it is worth noting that in some countries, such as Uganda, infusion is the most commonly used method. This difference highlights the cultural aspect of medicinal plant preparation, which varies according to local traditions [48].

Smearing was found to be the most commonly used method of administration (50.98%) across all departments. The use of this method could be explained by the fact that it allows the plant's active ingredients to be applied directly to the site of the bite or sting, thereby accelerating the therapeutic effect and the healing process. However, this practice could also be linked to Senoufo cultural traditions, since other studies have shown that the oral method is the most widely used method in envenomation treatment [37, 48].

5. Conclusion

This ethnobotanical study provides valuable information that contributes to a better understanding of anti-venom medicinal flora and helps preserve local traditional knowledge in the Poro region (Côte d'Ivoire). It can also constitute a database for the valorization of medicinal plants with a view to discovering new active ingredients that can be used in pharmacology. At the end of the ethnobotanical investigation, 51 plant species divided into 30 families were listed. The Fabaceae family was found to be the richest in species (11 species), followed by Euphorbiaceae (5 species). In terms of socio-demographics, men accounted for the majority of respondents (96.23%), most of whom were over 50 years of age. The majority were unschooled (94.34%), reflecting the oral transmission of traditional knowledge. Decoction emerged as the most commonly used preparation method, while smearing was the main administration method. Six types of envenomation were identified, among which snakebites were the most frequently treated. The evaluation of the pharmacological efficacy of the extracts of the anti-venoms identified, by in vitro and in vivo tests, will confirm their therapeutic potential.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

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